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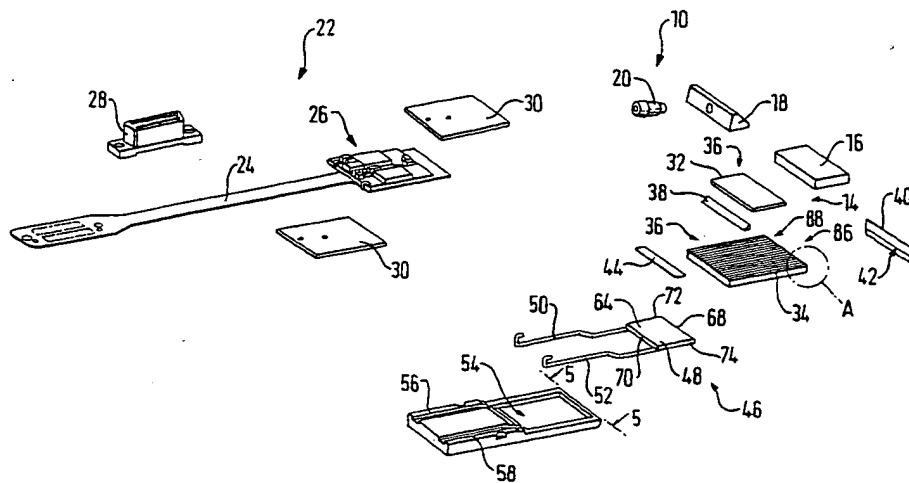
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(54) Title: AN INK JET PRINT HEAD

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(57) Abstract: An ink jet print head comprising: a top body portion (16), an intermediate body portion (14) having an upper side and a lower side, a plurality of ink channels (36) being disposed in a common plane along the upper side, each of said channels (36) having at least one orifice (42) for projecting ink towards a substrate, the upper side of the intermediate body portion (14) being located adjacent the top body portion (16); a main body portion (12) located adjacent the lower side of the intermediate body portion (14); and an ink heater (46) made of a PTC thermistor material (48), the ink heater (46) having a substantially planar configuration and being located between the lower side of the intermediate body portion (14) and the main body portion (12), the ink heater (46) extending in a plane parallel to the plane of the channels (36) and adjacent thereto. The ink heater (46) is designed to compensate for certain channels (88) which dissipate heat at a higher rate than other ink channels (86). The ink heater (46) includes electrodes (76, 78) formed on the PTC thermistor material (48) in an arrangement or pattern which compensates for the varying heat dissipation of the ink channels (86, 88).

An Ink Jet Print Head

This invention relates, generally, to an ink jet print head and, more particularly, to an improved print head ink temperature control device.

The prior art systems include drop-on-demand and continuous jet systems. In many cases, such systems use specially formulated inks for quick drying, clear marking and other characteristics which are desired by the user. These inks are temperature sensitive and therefore variation in ambient temperatures, such as in factories where products to be marked are being manufactured, adversely affect printing. Ink jet printing systems frequently locate the electronics and ink supplies remotely from the point where products are to be marked by the ink drops. The ink jet print head including the nozzle is located at the point of marking and may be connected to a cabinet by a relatively long ( $\frac{1}{2}$  to thirty foot) umbilical-like tube which supplies both ink and electrical control signals to the print head assembly.

It is somewhat difficult to maintain the ink at the optimum temperatures desired for best printing. For example, many ink jet systems are rated for use in environments within the temperature range of 40° and 120° Fahrenheit. Many inks, however, optimally operate within a temperature range of as little as plus or minus five degrees. For example, an ink formulated for use at 75° is desirably maintained between 70° and 80°F during printing operations. For this reason, control of the temperature of ink used in ink jet printing systems are known to be beneficial.

U.S. Patent No. 5,623,292 discloses a temperature controller for an ink jet printer. However, the temperature controller requires a temperature sensor and a control circuit. The temperature sensor and control circuit are potential failure items and increase the cost and

manufacturing complexity.

Japanese Published Patent Application JP 04336256A discloses a positive temperature coefficient (PTC) heater used to heat ink in channels of a print head. However, the design is somewhat complicated in that a plurality of PTC heaters are used and each PTC heater has an electrode on opposing sides of the heater. Japanese Published Patent Application JP 58053176A discloses a PTC thermistor for heating fluids and which has mutually isolated side electrodes to permit bi-directional current flow.

The use of PTC thermistors are also shown in, for example, U.S. Patent Nos. 5,015,986, 5,086,308 and 5,784,089, and Japanese Published Application JP 04345852A.

According to a first aspect of the present invention there is provided an ink jet print head comprising: a plurality of ink channels/chambers disposed in a common plane, each of said channels/chambers having at least one orifice for projecting ink towards a substrate; and an ink heater made of a thermistor material, the ink heater having a substantially planar configuration and extending in a plane generally parallel to the plane of the ink channels/chambers and adjacent to the ink channels/chambers.

Preferably, the print head comprises: a top body portion; an intermediate body portion having an upper side and a lower side, said plurality of ink channels/chambers being disposed in said common plane along the upper side, the upper side of the intermediate body portion being located adjacent the top body portion; and a main body portion located adjacent the lower side of the intermediate body portion, said ink heater being located between the lower side of the intermediate body portion and the main body portion.

According to a second aspect of the present invention there is provided a thermistor for heating ink in an ink jet print head, comprising: a planar member made of thermistor material

having a positive temperature coefficient; and first and second electrodes extending on one side of said planar member.

In a preferred embodiment, the ink heater is designed to compensate for an ink jet print head having certain ink channels which dissipate heat at a higher rate than other ink channels.

5 In particular, the ink heater includes electrodes formed on the PTC thermistor material in an arrangement or pattern which compensates for the varying heat dissipation of the ink channels.

An advantage of the embodiment of the present invention is that it provides an ink jet print head having a heater which can maintain ink temperature within a predetermined, acceptable range of temperatures.

10 A further advantage of the embodiment of the present invention is that it provides a print head heater which maintains the temperature of ink in the multiple channels or chambers at a uniform temperature.

A further advantage of the embodiment of the present invention is that it provides an ink heater which compensates for a print head having some ink channels which dissipate heat at 15 a rate different than the other ink channels.

A further advantage of the embodiment of the present invention is that it provides a print head having an ink heater which is less costly to manufacture and has an improved life span.

The invention will now be described, by way of example, with reference to the 20 accompanying drawings, in which:-

FIG. 1 is a perspective view of an ink jet print head, including a flex-circuit with a connector, in accordance with the present invention;

FIG. 2 is an enlarged view of the print head of FIG. 1;

FIG. 3 is an exploded view of the print head of FIG. 1;

FIG. 4 is an enlarged view of detail A from FIG. 3, showing the ink channels;

FIG. 5 is a view of the main body portion of the print head taken along line 5-5 in FIG. 3;

5 FIG. 6 is a perspective view of the ink heater of the print head of FIG. 1 secured to the intermediate and top body portions; and

FIG. 7A-7H show various configurations of the first and second electrodes on the thermistor material of the ink heater.

FIGS. 1 and 2 show a print head 10 for an ink jet printer in accordance with the present 10 invention. The print head 10 includes a main body portion 12, intermediate body portion 14, and top body portion 16. An ink manifold 18 is shown to include an external ink conduit 20 which receives the ink from an ink supply (not shown). The print head 10 includes a control flex-circuit 22.

FIG. 3 shows an exploded view of the print head 10 of FIG. 1. The control flex-circuit 15 22 includes a flex-circuit 24, components 26, connector 28 and a pair of plates 30 which provide rigidity to the flex-circuit 24 in the area of the components 26. It can be seen from FIG. 3 that the intermediate portion 14 includes a first piezo electric member 32 which is secured to a second piezo electric member 34 via an electrically conductive adhesive (not shown). FIG. 4 shows an enlarged view of a detail A from FIG. 3, showing a plurality of ink 20 channels 36 in the second piezo electric member 34. The ink channels 36 extend upwardly and through the first piezo electric member 32. A back seal 38 is used to hydraulically seal the intermediate body portion 14 and top body portion 16. Thus, the bottom face of top body portion 16 effectively forms the top side of ink channels 36, the bottom side of channels 36

having been formed in second piezoelectric member 34. A plate 40 includes a plurality of orifices 42. The plate 40 is secured to the intermediate body portion 14 with the orifices 42 aligned with respective ink channels 36. An electrically conductive adhesive 44 is used to electrically couple the control flex-circuit 22 to the intermediate body portion 14. The ink manifold 18 delivers the ink to the ink channels 36 via the top body portion 16. An ink heater 46 includes a ceramic PTC thermistor portion 48 and a first lead 50 and second lead 52. The main body portion 12 is shown to include a recess 54 and first lead groove 56 and second lead groove 58.

FIG. 5 is a view of the main body portion 12 taken along line 5-5 of FIG. 3 and more 10 clearly shows the recess 54 and first lead groove 56 and second lead groove 58. It can be seen that the first and second lead grooves 56, 58 extend into the recess 54 at inclined portions 60. The recess 54 receives the PTC thermistor portion 48 and the first and second lead grooves 56, 58 receive the first and second leads 50, 52 respectively.

As can be seen from FIG. 6, the PTC thermistor portion 48 is secured to the 15 intermediate body portion 14 via thermally conductive adhesive 62. As such, the PTC thermistor portion 48 extends across the width of the intermediate body portion 14. With the PTC thermistor portion 48 secured in this manner, the heat generated by the ink heater 46 is more uniformly distributed to the ink channels or chambers 36. An insulating air gap is formed in the recess 54 between thermistor portion 48 and main body portion 12. It should be noted 20 that FIG. 4 discloses ink channels 36. However, the present invention applies equally as well to print heads such as the type disclosed in U.S. Patent No. 4,901,093 wherein ink chambers are provided that hold ink behind the orifice so that ink drops are ejected from the orifice when longitudinally moving transducers apply pressure to the ink in the channels. The terms "ink

"channels" and "ink chambers" are used interchangeably herein and are intended to cover both embodiments.

FIGS. 3 and 6 show that the PTC thermistor portion 48 includes an upper side 64 and a lower side 66. FIG. 6 shows that the PTC thermistor portion 48 includes a first longitudinal edge 68, second longitudinal edge 70, first transverse edge 72 and second transverse edge 74. The lower side 66 of the PTC thermistor portion 48 includes a first electrode 76 which extends adjacent to the first longitudinal edge 68, and a second electrode 78 which extends adjacent to the second longitudinal edge 70. The first lead 50 is electrically coupled and secured to the first electrode 76 via a solder bump 80. Insulator 82 is provided to insulate the first lead 50 from the second electrode 78. The second lead 52 is electrically coupled and secured to the second electrode 78 via a solder bump 84.

FIG. 2 shows that the first and second leads 50, 52 are coupled to the print head control flex-circuit 22. When the print head control flex-circuit 22 couples a voltage across the first and second leads 50, 52, current will flow and begin to heat the ink heater 46. Since the PTC thermistor portion 48 is in a NTC region when first energized, heating causes the resistance of the PTC thermistor portion 48 to drop. The decreasing resistance, in turn, causes more current to flow which heats the part still further. If the voltage is high enough, the PTC thermistor portion 48 will self-heat until it passes into the PTC region of resistance. Once in the PTC region, the PTC thermistor portion 48 reaches a point where  $I^2R$  heat generated by the part is sufficient to make up for the loss of heat to the environment. In this situation, the PTC thermistor portion 48 is in equilibrium. If it starts to decrease in temperature, the resistance will decrease, drawing more current and countering the cooling tendency. Conversely, any tendency to increase the temperature meets just the opposite effect. In this condition, the PTC

thermistor portion 48 is automatically stabilized at a fixed temperature. Thus, the PTC thermistor 48 will maintain an operating temperature for a given voltage for ambient temperature below the set temperature of the PTC thermistor. The set or switching temperature is established by the PTC material and manufacturing process. The operating temperature can  
5 be changed by changing the voltage across the leads 50, 52.

In addition, since the first and second leads 50, 52 are on the same side (i.e., the lower side 66) of the PTC thermistor portion 48,  $I^2R$  heating is generated between the first and second electrodes 76, 78 and on the lower side 66.

The particular configuration of the print head 10 provides further advantages. FIG. 4  
10 shows that the ink channels 36 include ink channels 86 located near the center of the print head 10, and ink channels 88 which are located near the side of the print head 10. Because of the arrangement and location of the ink channels 36, certain of the ink channels will dissipate heat faster than the other channels. The first and second electrodes 76, 78 are screened onto the PTC thermistor portion 48 in a pattern that thermally tunes the ink heater 46 to the specific  
15 application. Advantage is taken of the fact that the PTC thermistor portion 48 has a room temperature ( $R_{25}$ ) resistance per lineal dimension. That is, the shorter the distance between the first and second electrodes 76, 78, the lower the resistance and the greater the current draw and heat applied in that area when power is applied. In most applications, the side ink channel 88  
dissipate heat faster than the center ink channel 86 because the center ink channels 86 are  
20 adjacent other heated channels, whereas the side ink channel 88 are adjacent a portion of the print head 10 which is exposed to the atmosphere. In addition, the closer the first and second electrodes 76, 78 are arranged the faster the ink heater 46 will reach equilibrium.

FIGS. 7A-7H disclose the PTC thermistor portion 48 with the first and second

electrodes 76, 78 having various patterns in order to thermally tune the ink heater 46 to a specific application. FIG. 7A-C disclose an electrode pattern wherein a constant temperature is generated across the PTC thermistor portion 48 between the first and second electrodes 76, 78. FIGS. 7D and 7E disclose an electrode pattern wherein heat is generated on the PTC thermistor portion 48 in a U-shaped pattern. FIG. 7F discloses an electrode pattern where more heat is generated in the center of the PTC thermistor portion 48 than along the first and second transverse edges 72, 74. Such an arrangement is effective wherein the center ink channels 86 dissipate more heat than the side ink channel 88. FIG. 7G and 7H disclose an electrode pattern where more heat is generated along the first and second transverse edges 72, 74 than at the center of the PTC thermistor portion 48. The pattern of FIGS. 7G and 7H are effective, for example, wherein the side ink channels 88 dissipate heat at a rate greater than the center ink channels 86.

CLAIMS:

1. An ink jet print head comprising: a plurality of ink channels/chambers (36) disposed in a common plane, each of said channels/chambers (36) having at least one orifice (42) for projecting ink towards a substrate; and an ink heater (46) made of a thermistor material (48),  
5 the ink heater (46) having a substantially planar configuration and extending in a plane generally parallel to the plane of the ink channels/chambers (36) and adjacent to the ink channels/chambers (36).
2. A print head according to claim 1 comprising: a top body portion (16); an intermediate body portion (14) having an upper side and a lower side, said plurality of ink  
10 channels/chambers (36) being disposed in said common plane along the upper side, the upper side of the intermediate body portion (14) being located adjacent the top body portion (16); and a main body portion (12) located adjacent the lower side of the intermediate body portion (14), said ink heater (46) being located between the lower side of the intermediate body portion (14) and the main body portion (12).
- 15 3. A print head according to claim 1 or claim 2, wherein the ink heater (46) is made of a thermistor material (48) having a positive temperature coefficient.
4. A print head according to claim 1 or claim 2 or claim 3, wherein the ink heater (46) is made of a ceramic thermistor material (48).
- 20 5. A print head according to claim 3, wherein the thermistor material (48) includes a first side (66) and a second side (64), and the ink heater (46) includes a first electrode (76) and a second electrode (78) located on the first side (66) of the thermistor material (48), whereby heat is generated on the first side (66) of the thermistor material (48) between the first (76) and second (78) electrodes.

6. A print head according to claim 5, further comprising a first lead (50) electrically coupled to the first electrode (76), and a second lead (52) electrically coupled to the second electrode (78).

7. A print head according to claim 5 or claim 6, wherein the ink heater (46) includes a  
5 first edge (68) and a second edge (70), the first edge (68) is located opposite from the second edge (70), the first (68) and second (70) edge extend in a direction which is substantially perpendicular to the plurality of ink channels/chambers (36), the first electrode (76) extends along the first edge (68) and the second electrode (78) extends along the second edge (70), whereby the first (76) and second (78) electrodes are opposite from one another and  
10 substantially parallel.

8. A print head according to claim 7, wherein the first electrode (76) extends near a center portion of the thermistor material (48), and the second electrode (78) extends near the center portion of the thermistor material (48), whereby the first and second electrodes (76, 78) are in close proximity to one another (Fig. 7C) so as to minimize the time the ink heater (46) reaches  
15 equilibrium.

9. A print head according to claim 5 or claim 6, wherein the plurality of ink channels/chambers (36) include one or more channels/chambers (86, 88) which dissipate heat at a higher rate than other channels/chambers (86, 88), and the first and second electrodes (76, 78) are located in an arrangement so that the thermistor material (48) generates greater heat in a  
20 first area located adjacent the one or more channels/chambers (86, 88) than a second area adjacent the other channels/chambers (86, 88).

10. A print head according to claim 9, wherein the plurality of ink channels/chambers (36) include outside channels/chambers (88) and inside channels/chambers (86), and the first and

second electrodes (76, 78) include a first end and a second end and a mid-portion, wherein the first and second ends are wider than the mid-portion (Figs. 7G, 7H), whereby greater heat is generated adjacent the outside channels/chambers (88) than adjacent the inside channels/chambers (86).

5 11. A print head according to claim 9, wherein the plurality of ink channels/chambers (36) include outside channels/chambers (88) and inside channels/chambers (86), the first and second electrodes (76, 78) include a first end and a second end and a mid-portion, wherein the first and second ends are narrower than the mid-portion (Fig. 7F), whereby greater heat is generated adjacent the inside channels/chambers (86) than adjacent the outside channels/chambers (88).

10 12. A print head according to claim 5 or claim 6, wherein the ink heater (46) includes a first longitudinal edge (68), a second longitudinal edge (70), a first transverse edge (72) and a second transverse edge (74), the first longitudinal edge (68) is located opposite from the second longitudinal edge (70), the first and second longitudinal edges (68, 70) extend in a direction which is substantially perpendicular to the plurality of ink channels/chambers (36), the first transverse edge (72) is located opposite from the second transverse edge (74), the first and second transverse edges (72, 74) extend in a direction which is substantially parallel to the plurality of ink channels/chambers (36), the second electrode (78) is substantially U-shaped and extends along the first and second longitudinal edges (68, 70) and the first transverse edge (72), and the first electrode (76) extends in an area defined by the U-shaped second electrode (78) and in a direction parallel to the first (68) and second (70) longitudinal edges (Figs. 7D, 7E).

13. A print head according to claim 2 wherein: said ink heater (46) is made of a thermistor material (48) having a positive temperature coefficient; the thermistor material (48) includes first (66) and second (64) sides; the ink heater (46) includes a first electrode (76) and a second

electrode (78) located on the first side (66) of the thermistor material (48), whereby heat is generated on the first side (66) of the thermistor material (48) between the first (76) and second (78) electrodes; and said print head further comprises a first lead (50) electrically coupled to the first electrode (76) and a second lead (52) electrically coupled to the second electrode (78).

5 14. A print head according to claim 13, wherein the main body portion (12) includes a recess (54) and a first (56) and second (58) groove extending in a longitudinal direction from the recess (54), wherein the recess (54) receives the thermistor material (48) and the first (56) and second (58) grooves receive the first (50) and second (52) leads, respectively.

10 15. A print head according to claim 14, wherein the thermistor material (48) is secured to the intermediate body portion (14) with thermally conductive adhesive (62), and an insulating air gap is formed in the recess (54) between the thermistor material (48) and the main body portion (12).

15 16. A print head according to any one of claims 13 to 15, further comprising a circuit (22) electrically coupled to the ink heater (46), wherein a voltage potential is applied across the first (50) and second (52) leads.

17. A thermistor for heating ink in an ink jet print head, comprising: a planar member (48) made of thermistor material having a positive temperature coefficient; and first and second electrodes (76, 78) extending on one side (66) of said planar member (48).

20 18. A thermistor according to claim 17, further comprising a first edge (68) and a second edge (70), the first edge (68) is located opposite from the second edge (70), the first electrode (76) extends along the first edge (68) and the second electrode (78) extends along the second edge (70), whereby the first and second electrodes (76, 78) are opposite from one another and substantially parallel.

19. A thermistor according to claim 17, wherein the first and second electrodes (76, 78) include means for thermally tuning the thermistor to the heat dissipation of ink channels/chambers (36) in the ink jet print head.

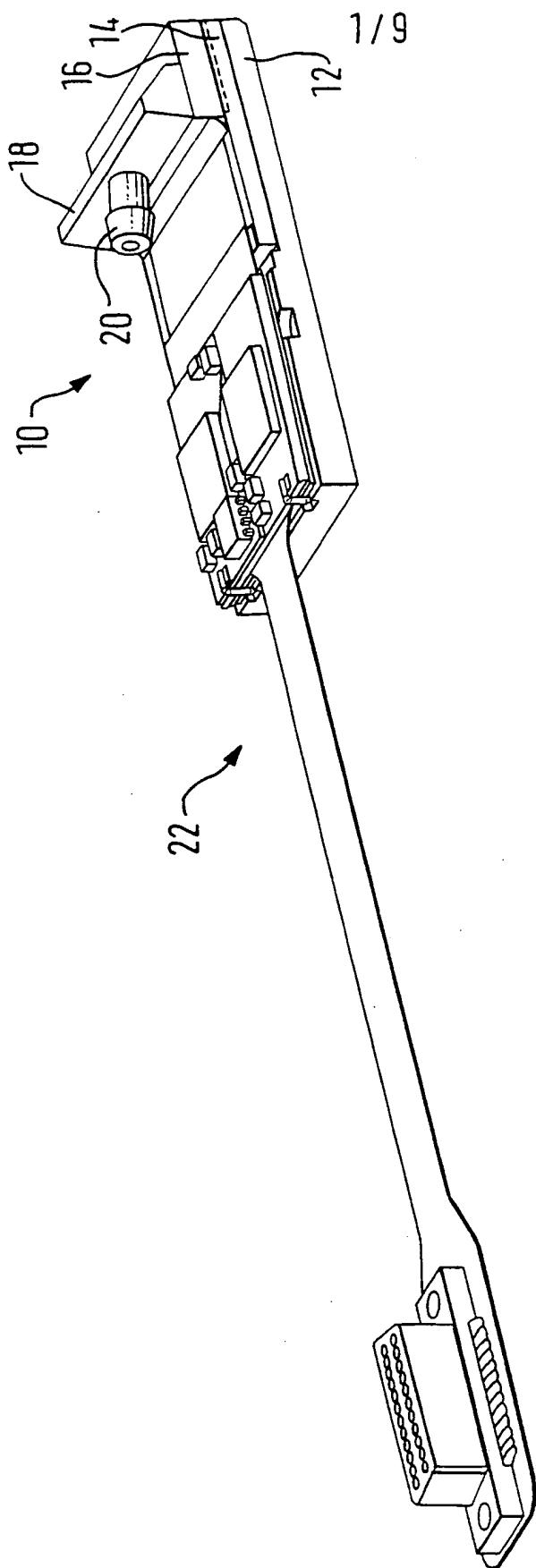


FIG. 1

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2/9

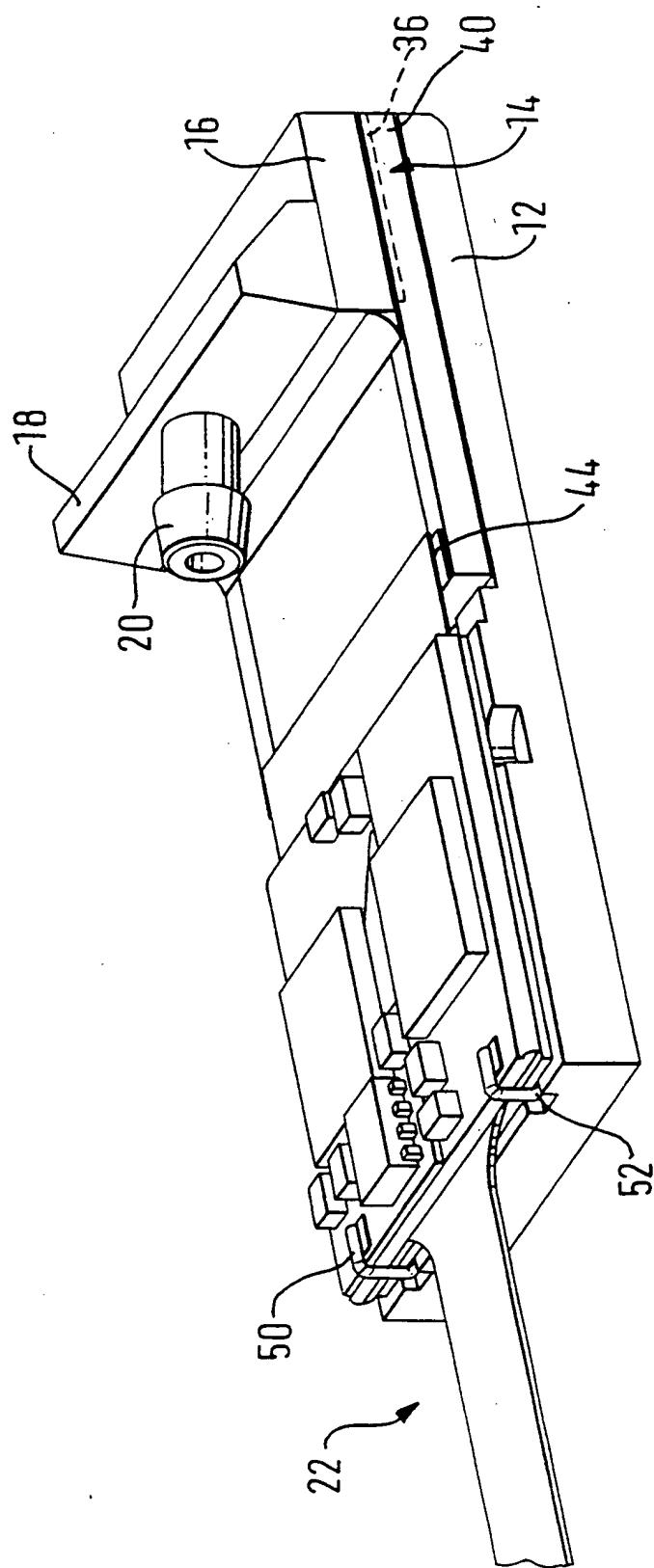


FIG. 2

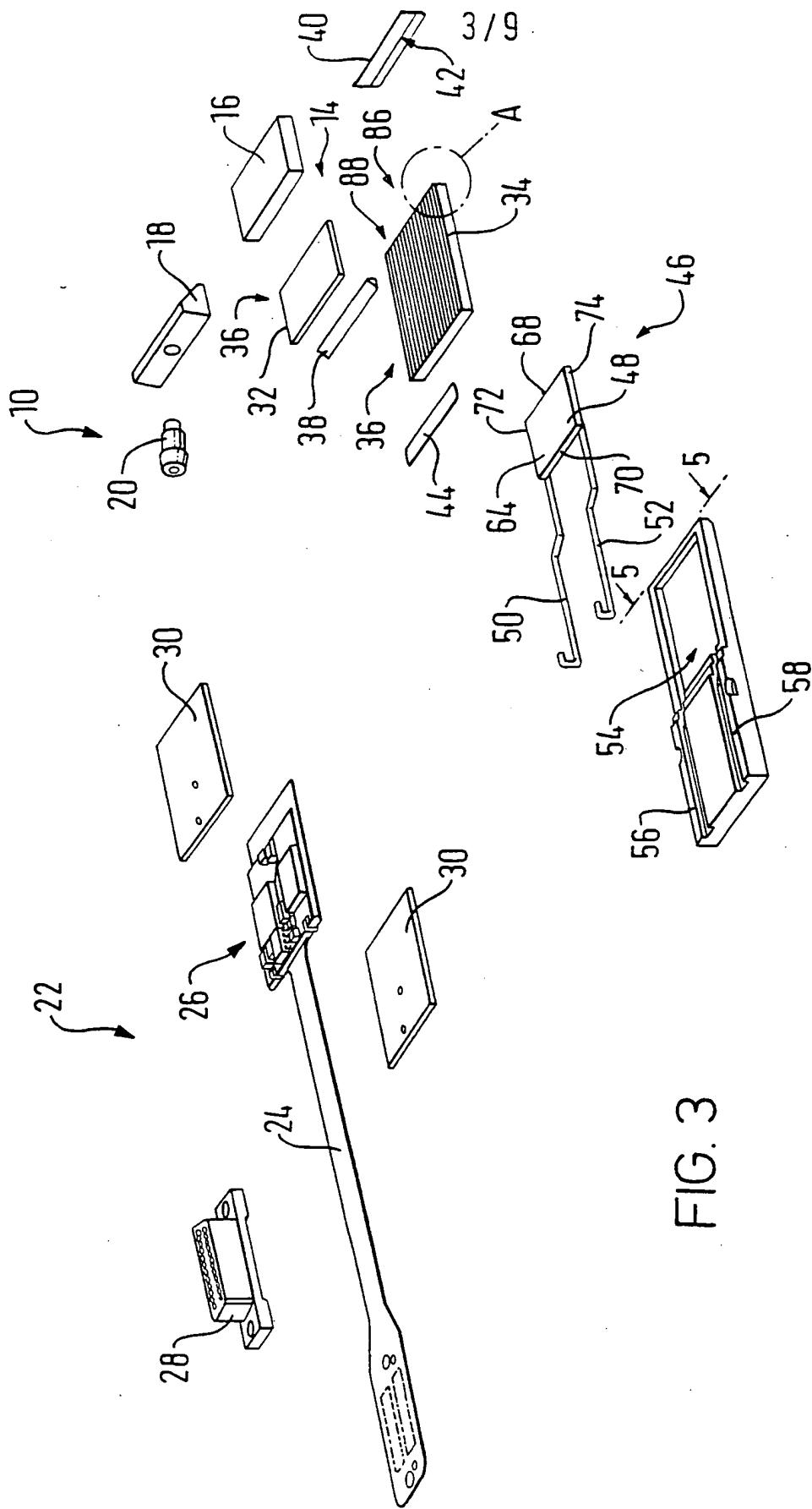


FIG. 3

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4 / 9

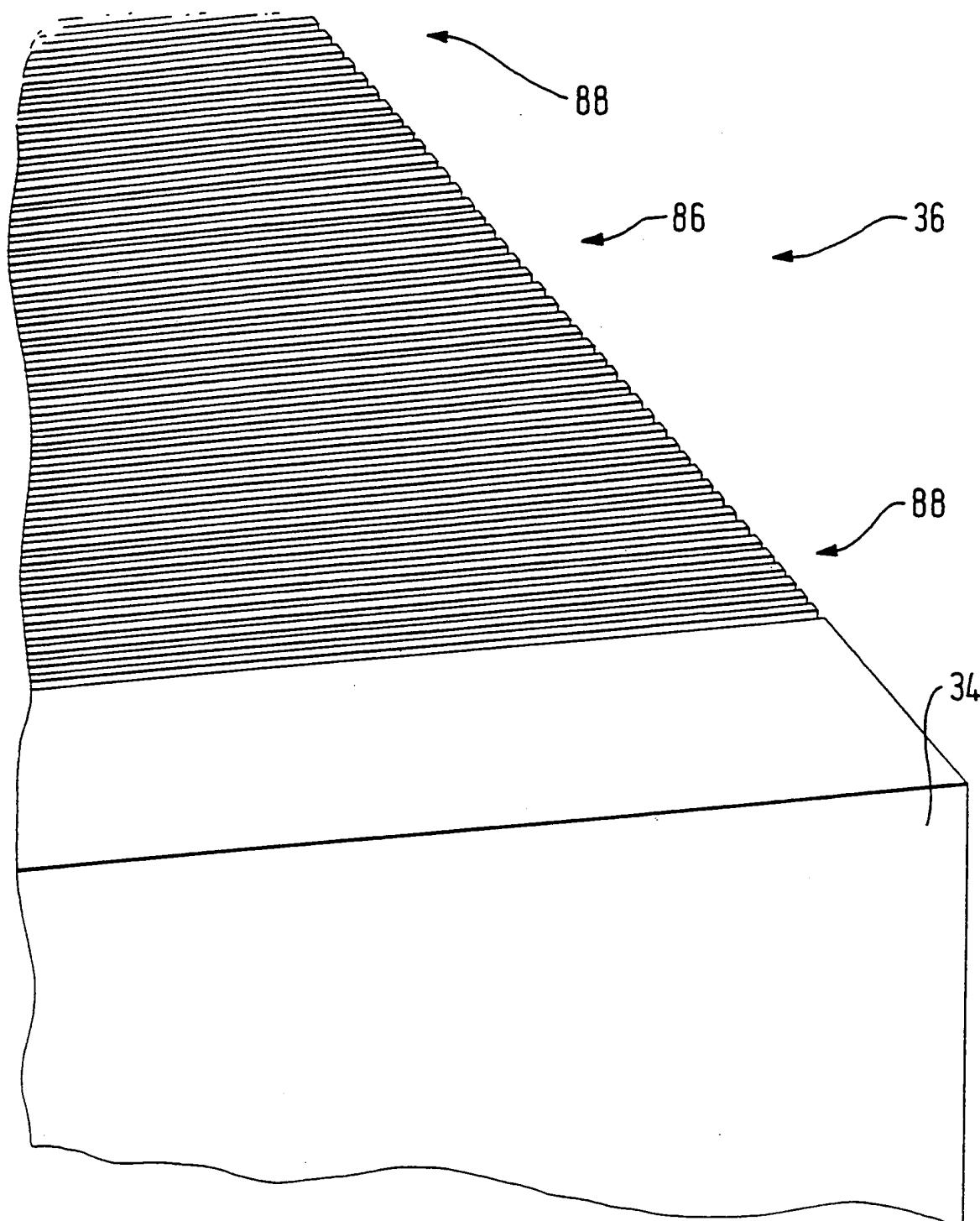


FIG. 4

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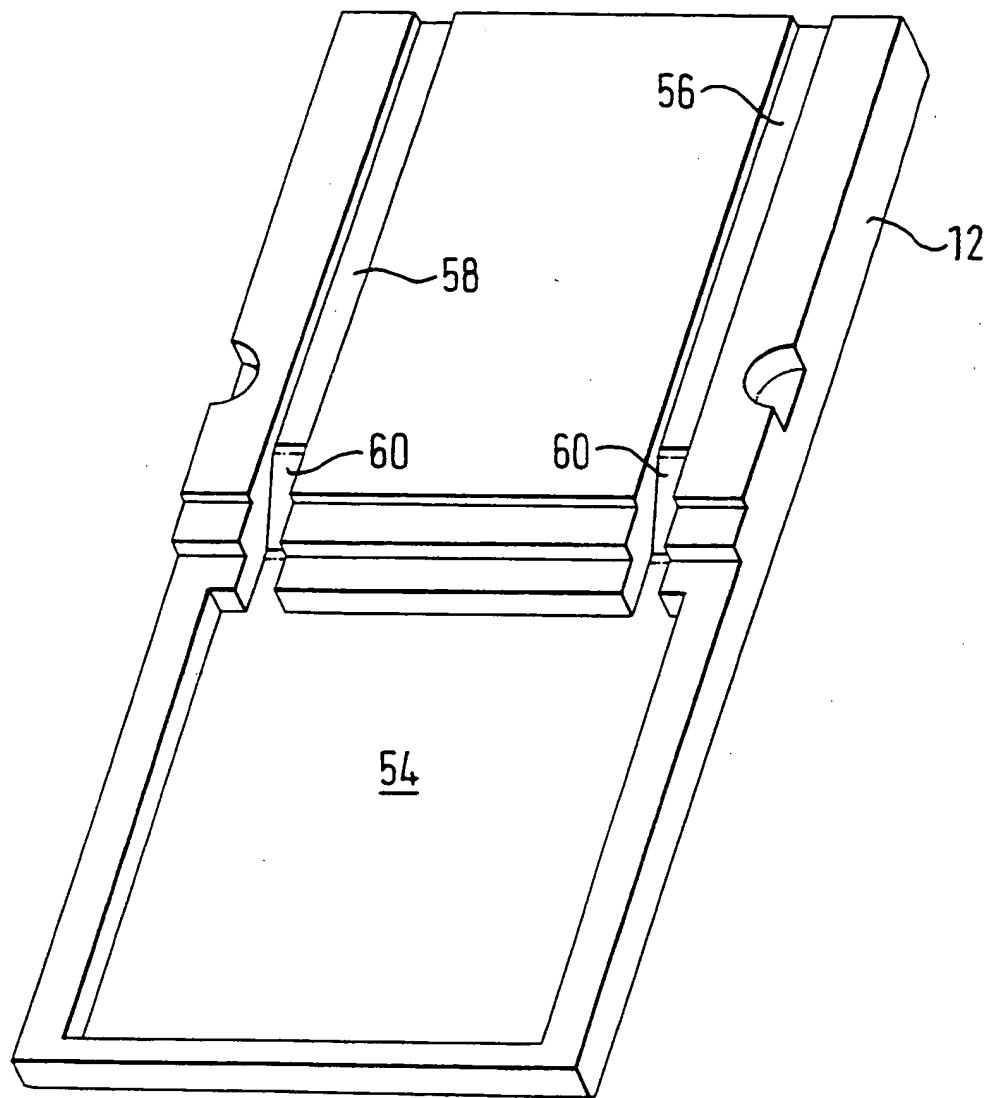


FIG. 5

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6/9

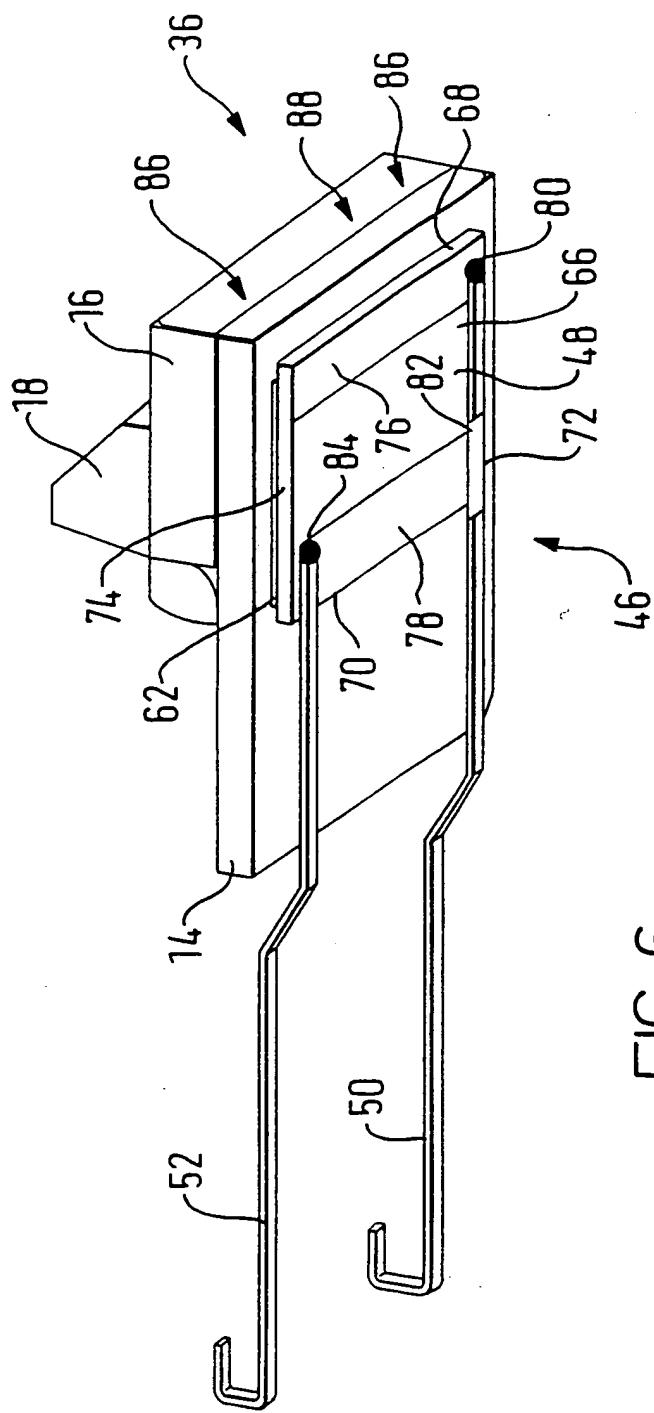


FIG. 6

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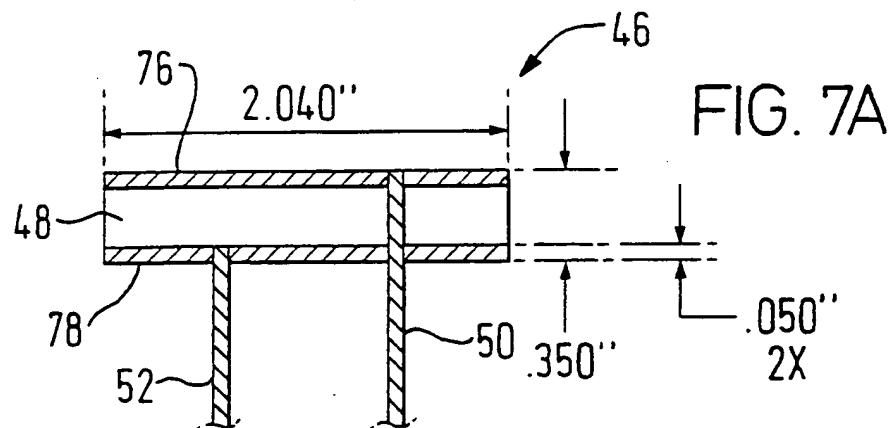


FIG. 7A

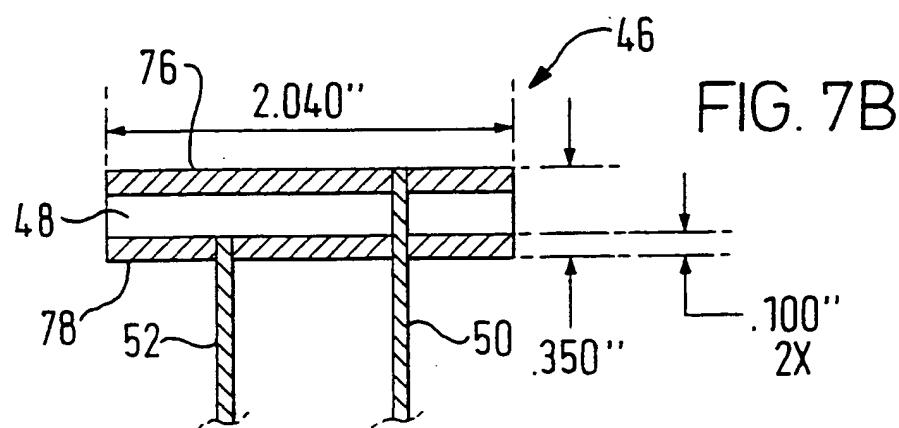


FIG. 7B

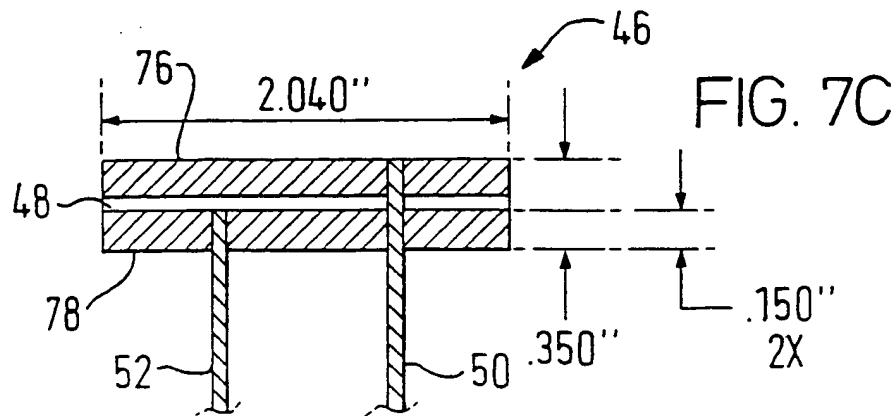
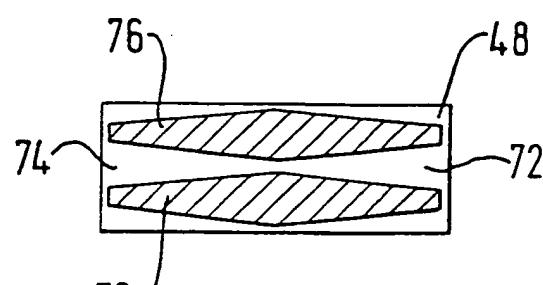
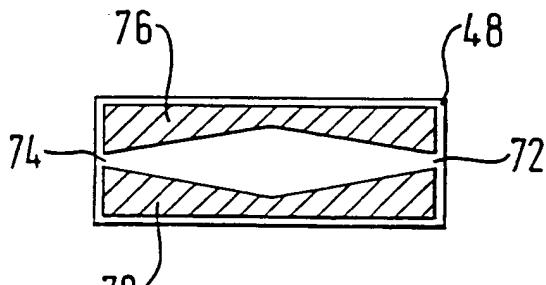
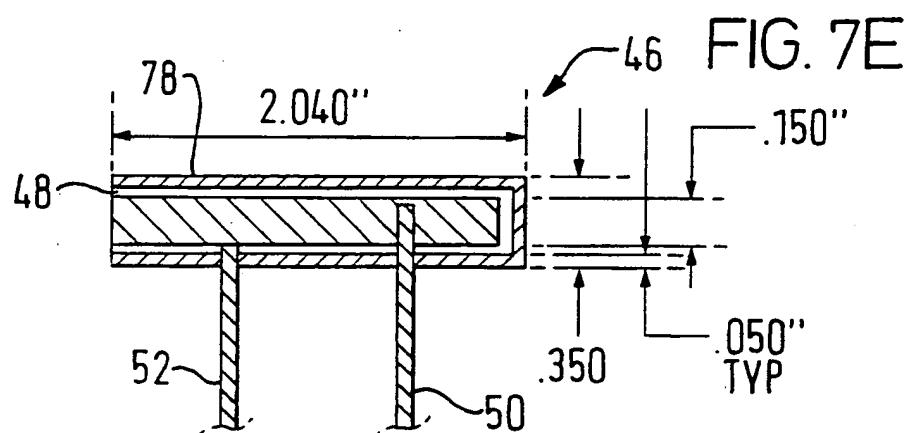
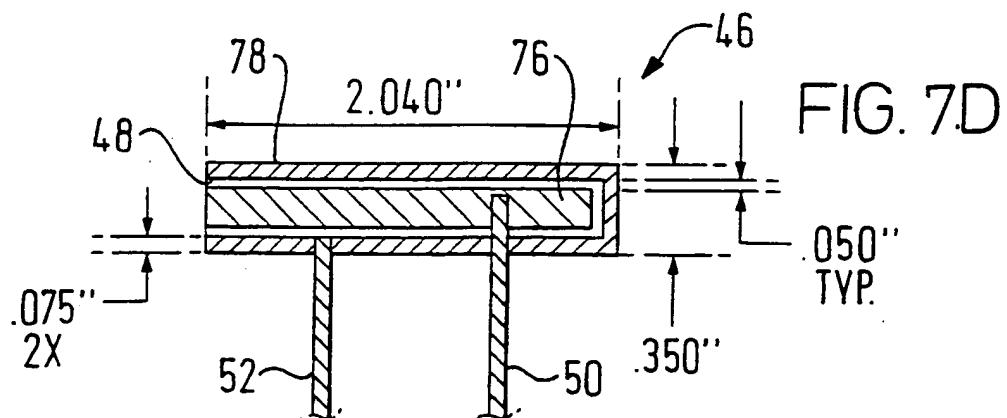


FIG. 7C

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8 / 9



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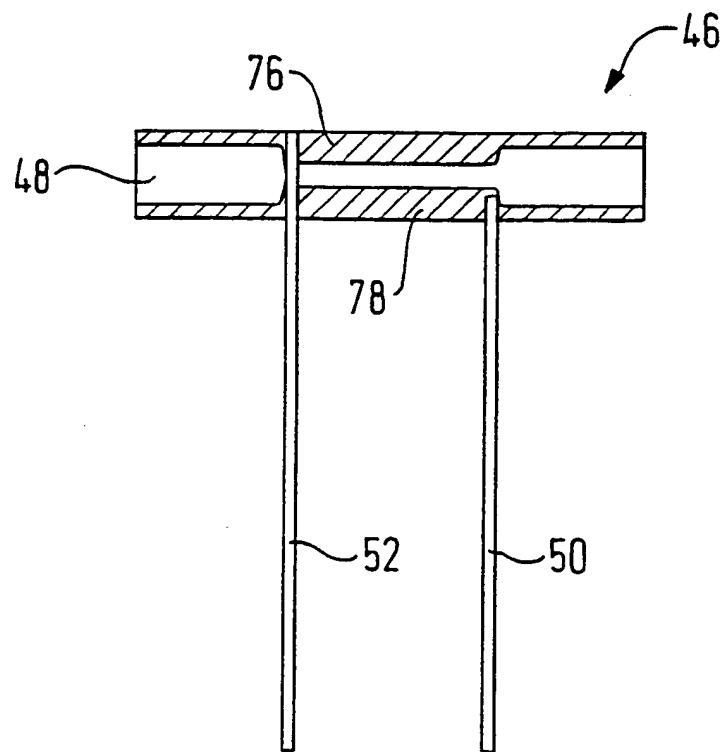


FIG. 7H

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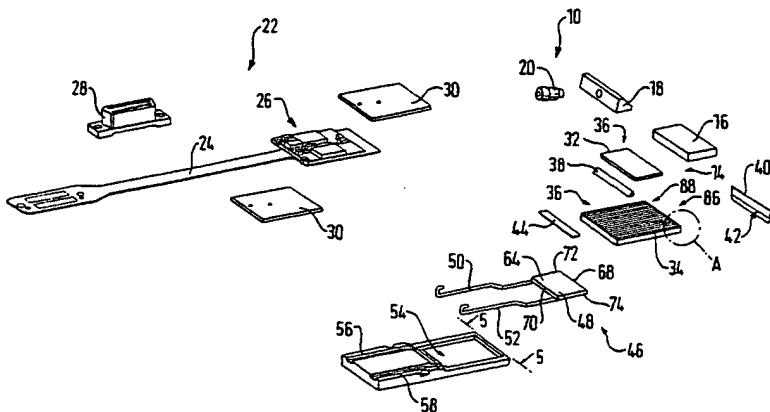
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(54) Title: AN INK JET PRINT HEAD



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(57) Abstract: An ink jet print head comprising: a top body portion (16), an intermediate body portion (14) having an upper side and a lower side, a plurality of ink channels (36) being disposed in a common plane along the upper side, each of said channels (36) having at least one orifice (42) for projecting ink towards a substrate, the upper side of the intermediate body portion (14) being located adjacent the top body portion (16); a main body portion (12) located adjacent the lower side of the intermediate body portion (14); and an ink heater (46) made of a PTC thermistor material (48), the ink heater (46) having a substantially planar configuration and being located between the lower side of the intermediate body portion (14) and the main body portion (12), the ink heater (46) extending in a plane parallel to the plane of the channels (36) and adjacent thereto. The ink heater (46) is designed to compensate for certain channels (88) which dissipate heat at a higher rate than other ink channels (86). The ink heater (46) includes electrodes (76, 78) formed on the PTC thermistor material (48) in an arrangement or pattern which compensates for the varying heat dissipation of the ink channels (86, 88).

# INTERNATIONAL SEARCH REPORT

Int'l. Appl. No  
PCT/GB 00/03386

**A. CLASSIFICATION OF SUBJECT MATTER**  
IPC 7 B41J2/14

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 B41J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

PAJ, EPO-Internal, WPI Data

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	PATENT ABSTRACTS OF JAPAN vol. 008, no. 227 (M-332), 18 October 1984 (1984-10-18) & JP 59 109370 A (EPUSON KK), 25 June 1984 (1984-06-25) abstract ---	1, 3
X	PATENT ABSTRACTS OF JAPAN vol. 014, no. 481 (M-1037), 19 October 1990 (1990-10-19) & JP 02 194960 A (SEIKO EPSON CORP), 1 August 1990 (1990-08-01) abstract ---	1
A	---	17 -/-

Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

\* Special categories of cited documents :

- \*A\* document defining the general state of the art which is not considered to be of particular relevance
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- \*O\* document referring to an oral disclosure, use, exhibition or other means
- \*P\* document published prior to the international filing date but later than the priority date claimed

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- \*X\* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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Date of the actual completion of the international search

28 February 2001

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Inte: ional Application No

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## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	PATENT ABSTRACTS OF JAPAN vol. 013, no. 334 (M-855), 27 July 1989 (1989-07-27) & JP 01 110963 A (SEIKO EPSON CORP), 27 April 1989 (1989-04-27) abstract ----	1,17
A	PATENT ABSTRACTS OF JAPAN vol. 016, no. 440 (M-1310), 14 September 1992 (1992-09-14) & JP 04 152147 A (FUJI XEROX CO LTD), 26 May 1992 (1992-05-26) abstract ----	1,17
A	PATENT ABSTRACTS OF JAPAN vol. 016, no. 090 (M-1218), 5 March 1992 (1992-03-05) & JP 03 272854 A (SEIKO EPSON CORP), 4 December 1991 (1991-12-04) abstract ----	1,17
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Information on patent family members

International Application No

PCT/GB 00/03386

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